Off-Plane (Conical) vs In-Plane RGS Mounts

- Off-plane offers higher efficiency, factor of 2-3 more than in-plane, due to more advantageous groove illumination function. Can be as high as 50-60%.
- Also offers potentially higher spectral resolution.
- Biggest difference to in-plane geometry is polarization sensitivity, predicted using the code PCGRATE developed by Leonid Goray et al.

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I will discuss the origin and nature of the polarization response, ongoing experimental validation of the code, and possible strategies in grating design for minimizing, or at least controlling/understanding the polarization.

Efficiencies of 5000 gr/mm Off-Plane Gratings

- Gold coated, grazing incidence. Optimized for 15 Å incident wavelength.
- Three groove profiles: triangular, trapezoidal, polygonal.
- Grooves span a range of possibilities for selectively etched silicon plates.
- 7^o facet angle, 7^o polar incidence angle, vertical non-working facet.
- 0.5 nm roughness (additional calculations for 2 nm roughness).
- 88^o azimuthal incidence angle (additional calculations for 88.5^o).

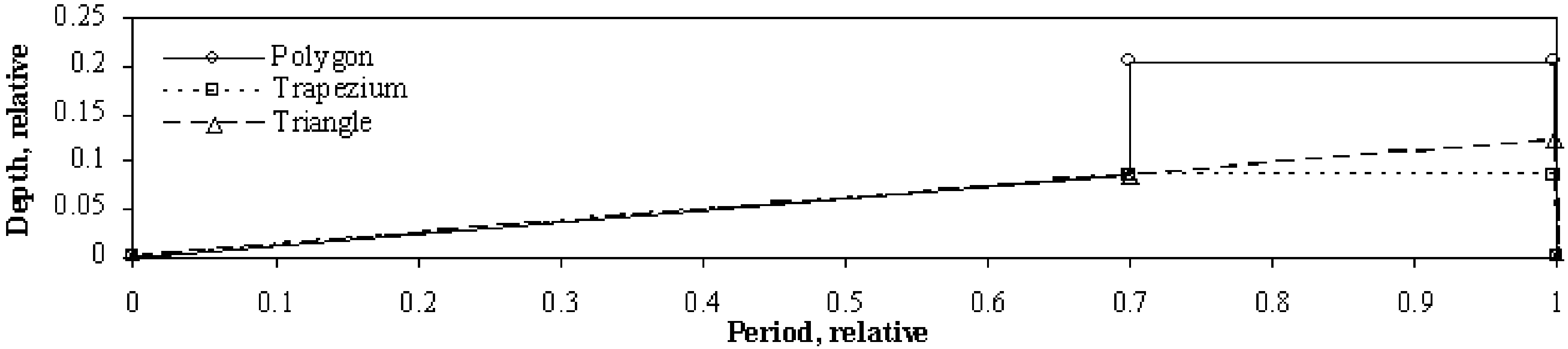


Fig. 7. Groove profile function of the polygon, trapezium, and triangle plotted in units of the period.

Strong Polarization Effects and Anomalies in the TM Efficiency

Triangular Groove

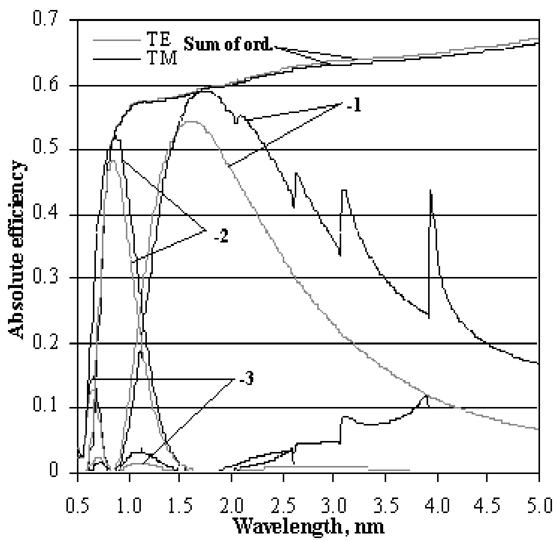


Fig. 8. Absolute efficiency in the –1, –2, and –3 orders of a 5000-gr/mm triangular grating with 7° working facet angle and 5-Å rms roughness calculated as a function of wavelength for the 7° polar and 88° azimuth incidence angles and the off-plane mounting.

Trapezoidal Groove

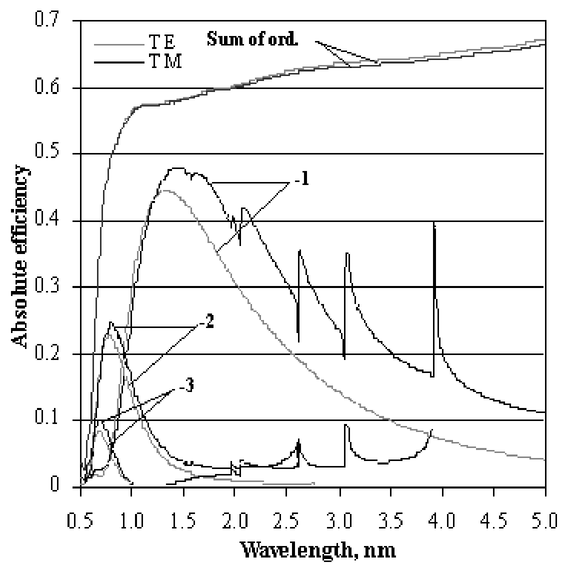


Fig. 9. Same as in Fig. 8 but for a trapezoidal grating.

Polygonal Groove

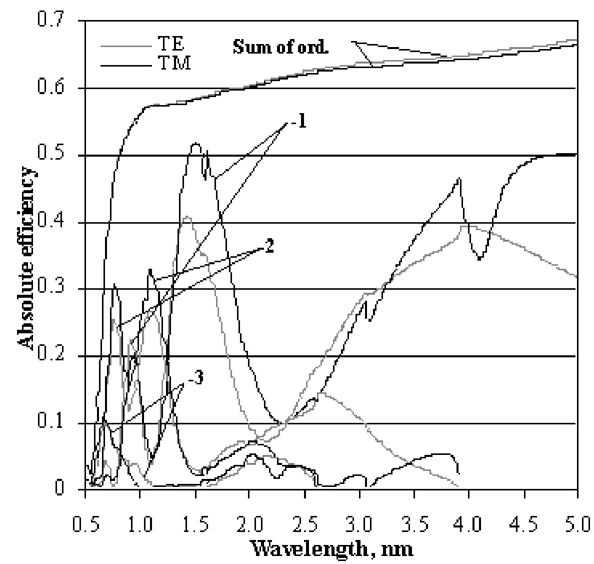


Fig. 10. Same as in Fig. 8, but for a polygonal grating.

Efficiency of 6000 gr/mm Off-Plane Gratings

Gold coated, triangular grooves. Optimized for 15 Å incident wavelength:

Left: 7.65° facet angle, 7.65° polar angle, 88° azimuthal angle.

Right: 10.3° facet angle, 10.3° polar angle, 88.5° azimuthal angle.

Stronger polarization effects than 5000 gr/mm (shorter period and deeper grooves).

Peak efficiencies >0.6.

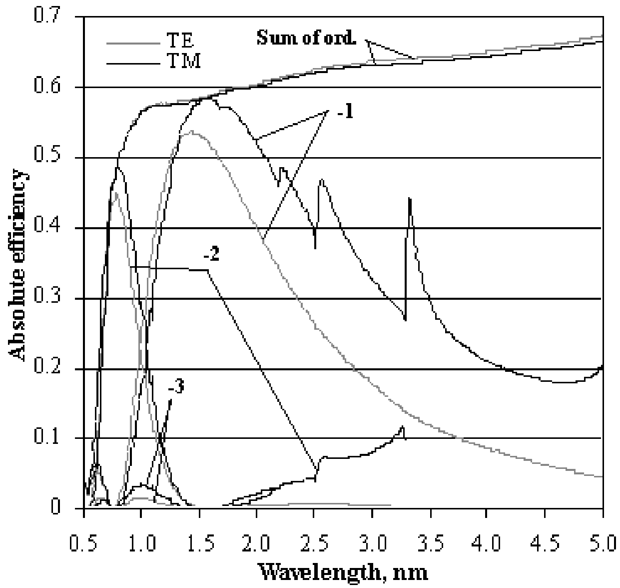


Fig. 14. Absolute efficiency in the –1, –2, and –3 orders of a 6000-gr/mm triangular grating with 7.65° working facet angle and 5-Å rms roughness calculated as a function of wavelength for the 7.65° polar and 88° azimuth incidence angles and the off-plane mounting.

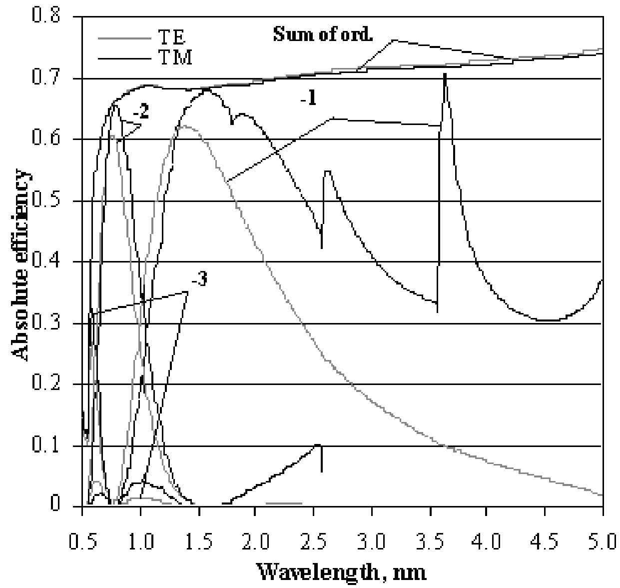


Fig. 15. Absolute efficiency in the –1, –2, and –3 orders of a 6000-gr/mm triangular grating with 10.3° working facet angle and 5-Å rms roughness calculated as a function of wavelength for the 10.3° polar and 88.5° azimuth incidence angles and the off-plane mounting.

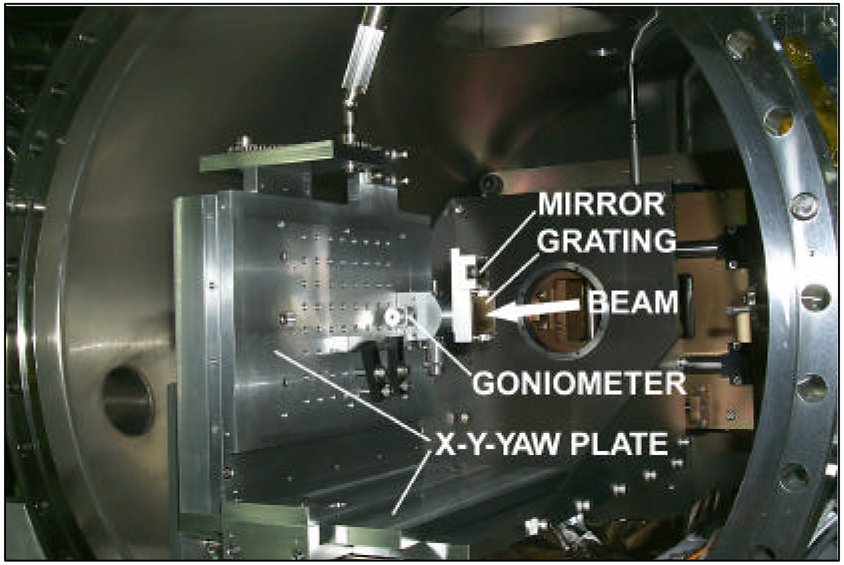
• The grating has 2400 L/mm, 3 deg blaze angle, and 0.5 nm microroughness.

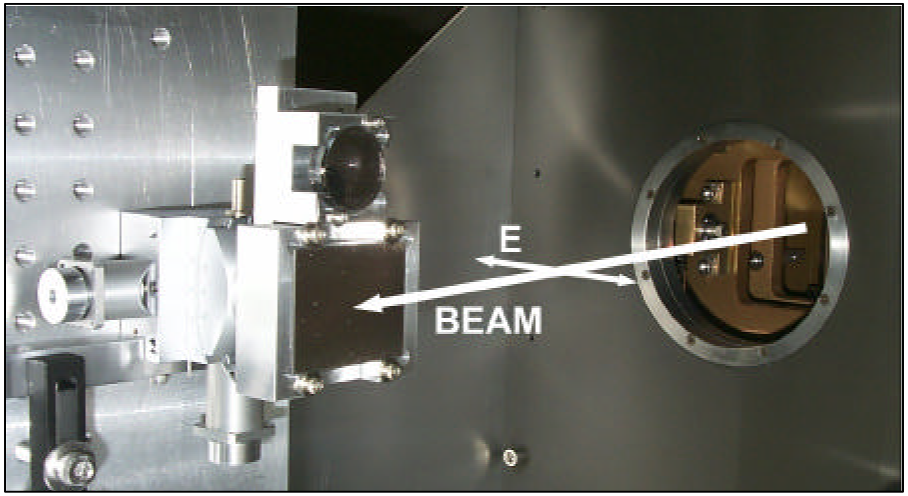
• The grating surface consists of a 74 nm SiO2 coating on oxidized aluminum.

• Mounted at NRL beamline X24C at the Brookhaven synchrotron with the grooves vertical (in-plane mount).

• Grazing angle is adjusted by a goniometer to 2 deg. Goniometer is mounted on a plate with x, y, and yaw motions.

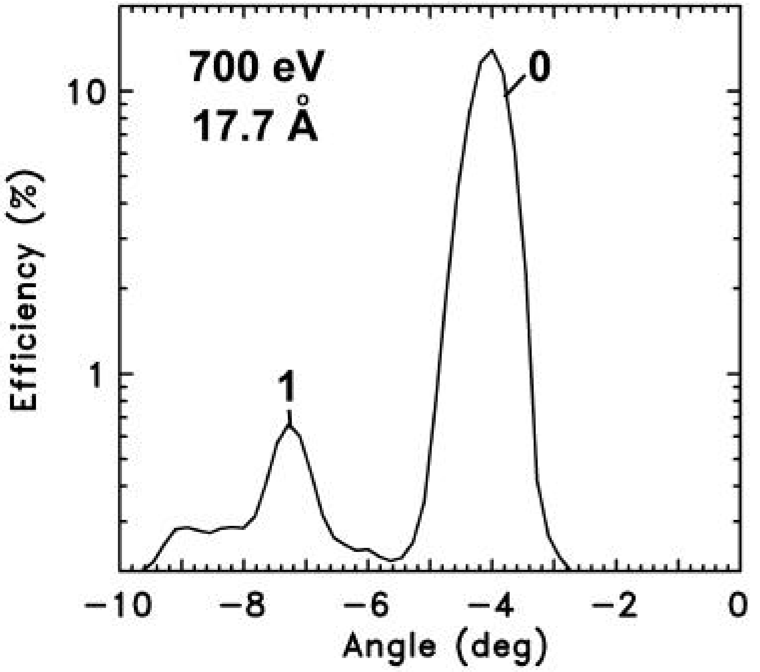
• Incident beam is 1 mm in size and has the electric vector horizontal, parallel to the plane of incidence (85% p polarized).

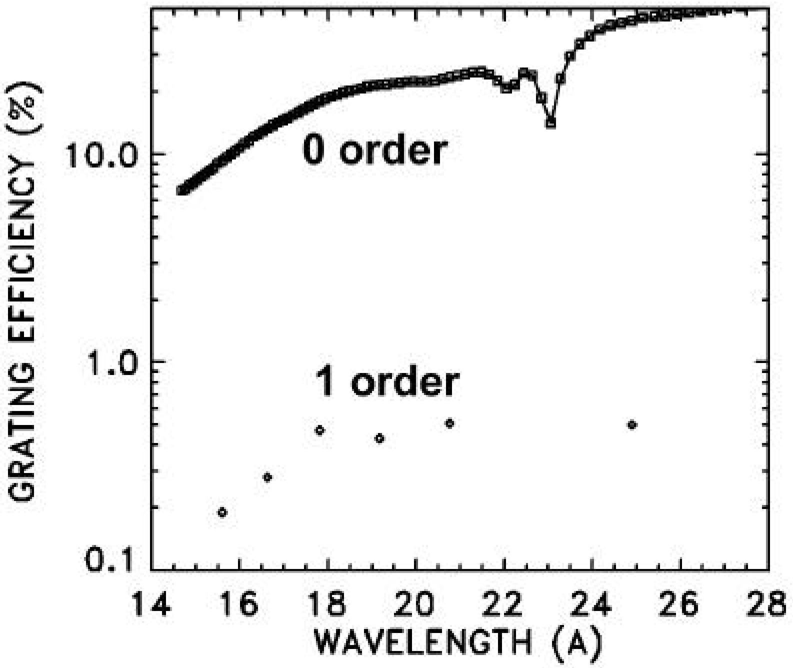




• **Left: The 0 and 1 order efficiencies measured at 700 eV by scanning the detector in angle through the orders. The angular width of the orders results from the 1 mm beam size and the detector slit.**

• **Right: The 0 and 1 order efficiencies measured over the wavelength range 14-28 Å. The oxygen K edge is visible at 23 Å in the 0 order data and indicates the spectral resolution.**

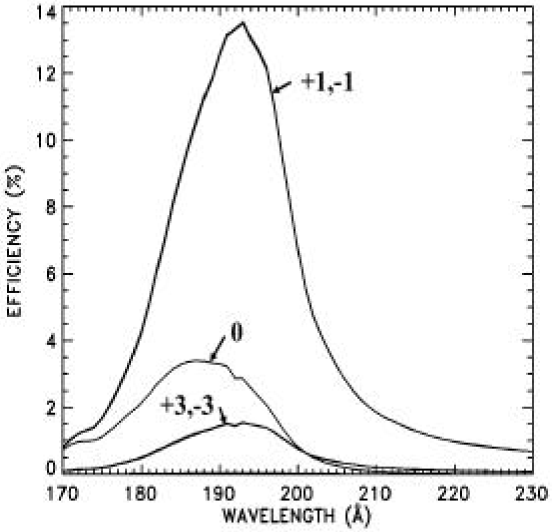


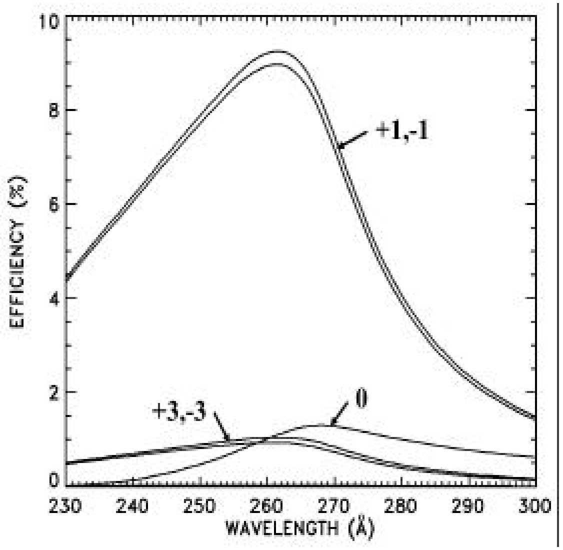


Mo/Si Laminar Grating for the EIS Spectrometer

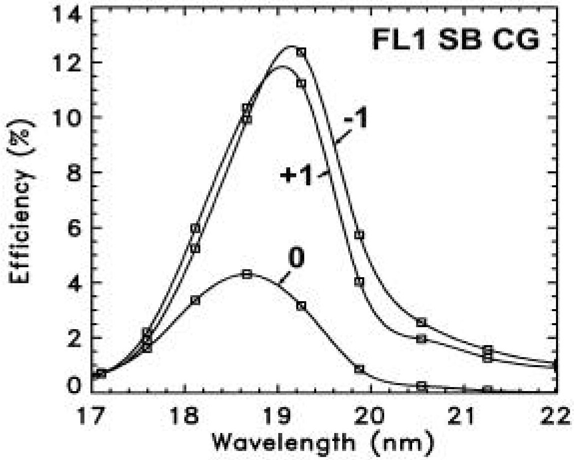
The PCGRATE code predictions and the measured efficiencies are in excellent agreement:

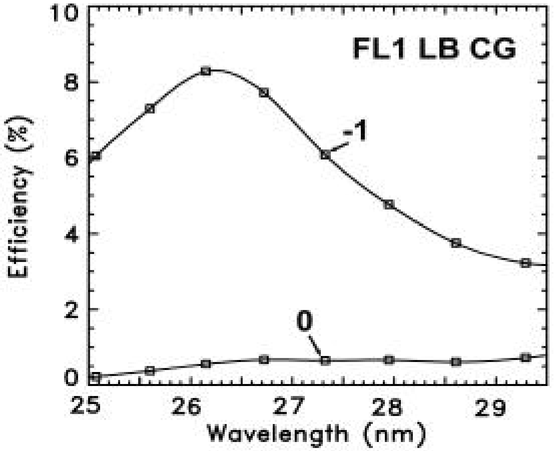
EIS grating efficiencies predicted using PCGRATE and published in SPIE 2000:





EIS grating efficiencies measured in 2003:





Polarization in Solar/Stellar Flares?

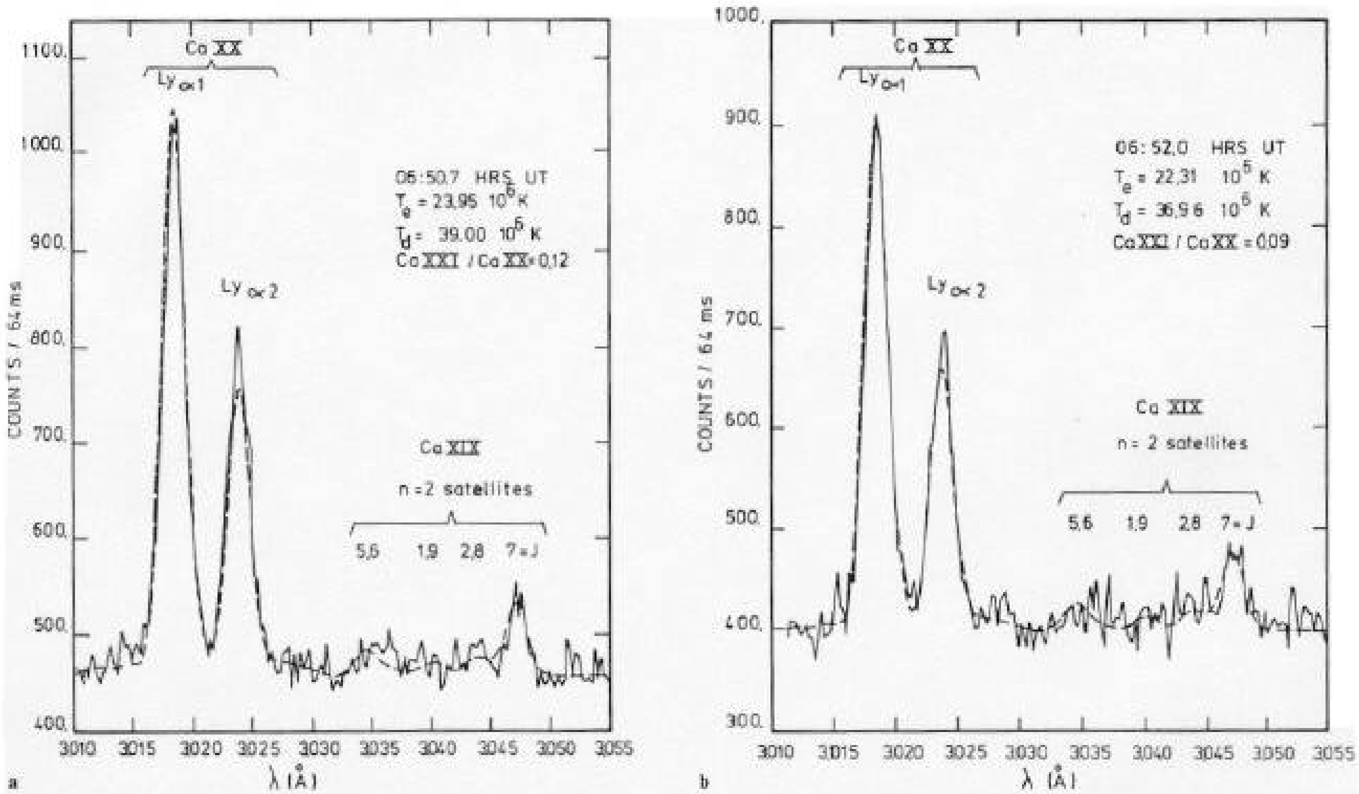


Fig. 2a and b. Spectra from the 27 April 1979 event just after flare maximum (**a**) and during decay (**b**). The full lines are the observed spectra, the broken lines are the synthetic spectra adjusted from the present data. T_e and T_d are the best fit values respectively of the electron and the Doppler temperatures. The best fit values of the ion ratio have been obtained assuming ionization equilibrium. The main $n = 2$ satellites are designated according to the key given in Table 4

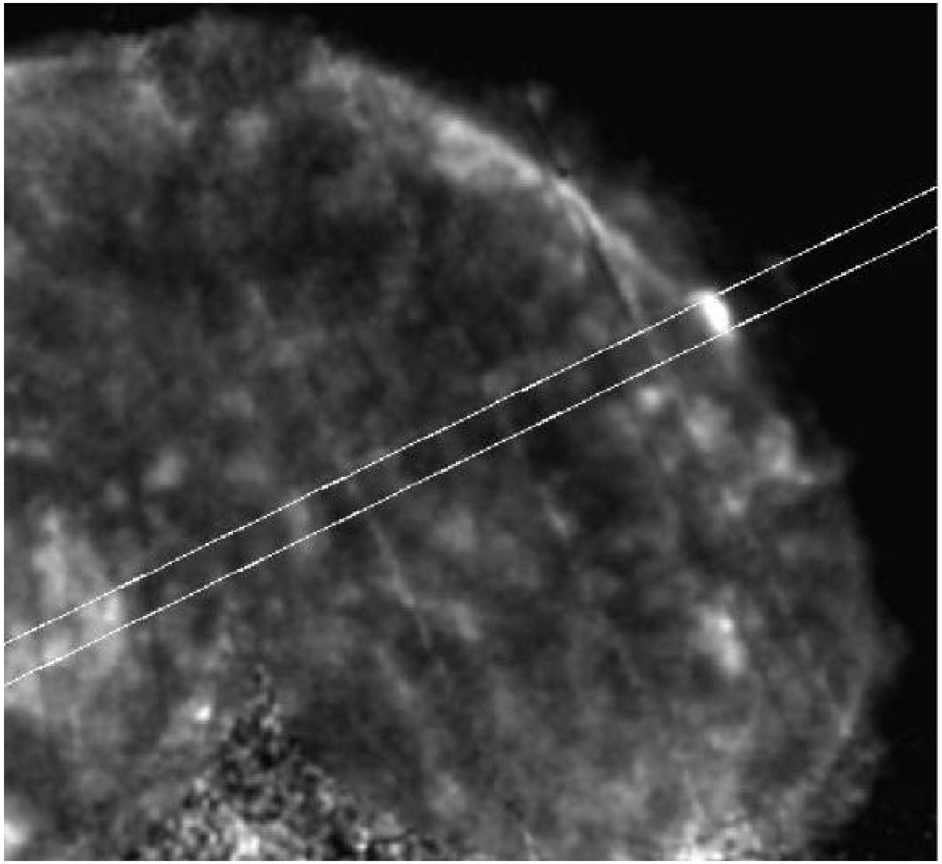
NRL SOLFLEX on P78-1 (Blanchet et al. 1985, A&A, 152, 417)

Anomalous ratio of Lya$_1$:Lya$_2$ in Ca XX

Polarization or opacity?

No direct polarization detections (with rotating Bragg crystals) so far in solar flare observations.

Polarization at Collisionless Shock Fronts



SN 1006 NW limb imaged in 0.50-0.61 keV by XMM-Newton (O I-VII K shell lines, Vink et al. 2003, ApJ, 587, L31).

Evidence for collisionless electron heating to about 1 keV by several authors (Laming et al. 1996, Ghavamian et al. 2002, Vink et al. 2003).

Energized electrons are non-Maxwellian and almost certainly "beamed" close to the shock front.

Expect to pick this up in polarization of lines formed close to shock (O I, II, III, etc K shell emission).